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ABSTRACT

This paper explores the conceptual aspect of educational technology, identifies recurring limitations of instructional technologies often overlooked by their proponents, and examines the politics of and barriers to educational innovation, particularly in the field of computer assisted instruction (CAI). It is noted that, despite glowing predictions for various mediums of instruction, educational technology in general has been shown to produce no significant difference in learning achieved through formal schooling. Also presented are lessons gained from attempts to implement instructional technology innovations which have relevance for the educational computing field: (1) the introduction of large, expensive media requires strong political support; (2) decision makers must be prepared to amortize high capital start-up costs over a long period of time; (3) a well-trained, skilled staff and an extensive infrastructure and educational support system are required; (4) cost estimates must be based on adequate production guidelines and cost effective means of distribution or communication that reach the largest possible audience; (5) close attention must be paid to the psychological and affective factors undergirding communication; (6) teachers must receive information about an innovation, training in its use, curriculum materials to assist in integrating the application, long-term support services, and incentives to change; and (7) courseware must be well designed and compatible with a philosophy of application that stresses creative and productive uses, word processing, information access and processing, simulations, and problem generation and solving. A 24-item bibliography is provided. (Author/ESR)

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PRISONERS OF THE CAVE: CAN INSTRUCTIONAL TECHNOLOGY IMPROVE EDUCATION?

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Prologue

In the seventh book of Plato's Republic a passage popularly called the "Allegory of the Cave" is used to depict "man's" level of awareness and intellectual development. Human beings are prisoners, the reader is informed, able only to see shadows and to hear only echoes of the truth.

> In other words, the view of men generally with regard to themselves and the world around them is a view distorted by falsifying media, by their own passions and prejudices... they are permanently in the state of understanding in which children are, except that they believe in the truth of what they see and hear with the force and tenacity of grown men.
>
> (Nettleship,1962:260)

To what extent does this state describe the quest of educational technologists, instructors, curriculum developers, and educational administrators to apply instructional technologies like computers to education? What is the goal to be achieved? Are there distinct advantages of one instructional technology or technique compared to all the others? If the advantages of computer-based instructional technology are self-evident why is CAI not widely adopted? Are there rational reasons for resisting the automation of education?

This paper will address these questions. It will identify some of the recurring limitations of instructional technologies which proponents often overlook. Barriers to educational innovation and the political context of change will also be examined. The paper will conclude by presenting some guidelines for optimizing instructional technologies and consolidating change. In the process this paper will reference a handful of articles and texts which, though they have had an important impact on the field of educational technology, may have been overlooked by practitioners of educational computing.

Utopian and Dystopian Prophecies

Countless articles, papers, and books published since the Third Canadian Symposium on Instructional Technologies have proclaimed the social benefits which computers will produce. The images of "the wired society" and "the electronic cottage" have captured the public's imagination. The benefits to be derived from the application of computers to education and learning have been optimistically predicted. These can be summarized as:

- equal opportunity of access to education for everyone
- an open, de-schooled educational environment
- flexibility of time and place of study
- access to vast amounts of information for everyone
- ability to locate and access desired information quickly
- ability to use the technology to process information
- ability for anyone to add to the information
- individualized pace and content of instruction
- lifelong learning will be promoted and assisted

These are admirable outcomes. Proponents of computer-based education believe sincerely that all these objectives can be attained. It is this utopian vision of a better education which motivates a considerable number of computerphiles and educational technologists. Is this the shadow or the reality?

Computer enthusiasts tend to dismiss pessimistic predictions concerning the impact of computers on education as either near sighted, conservative, or just plain stupid. Paul Saetler's History of Instructional Technology (1968) compiled a compelling list of concerns and issues associated with a wide range of pre-CAI instructional technologies. Many of these are still relevant. Educational planners, administrators and practitioner's have inherited an important social responsibility to ensure the effects of technology on students and learning are assessed fairly and thoroughly. Some of the reservations regarding computer-based education which require scrutiny include:

- an over reliance on operant as opposed to cognitive learning strategies.
- extension of teacher-centered instruction.
- inappropriate and poor instructional design resulting in learner boredom and frustration

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- continued "spatial distortion" in the distribution of resources resulting in an inequality of access (Elliott, 1975)
- creation of a technocratic, information rich elite
- advancement of a purely scientific model of education at the expense of aesthetic, self-actualization and discovery models.
- insufficient and poor quality courseware.
- inadequate integration of CAI into existing curriculum.
- the budget for education will be further diluted, hastening the decline.

These and other considerations will have to be addressed if the voices of the pessimists are to be silenced. Can advocates of computer-based instruction accomplish what sixty years of educational technology and audio visual instruction have not - a qualitative improvement and a transformation of the instruction process?

The Politics of Educational Innovation

The theme of this fourth symposium, "Computer Technologies for Productive Learning", either intentionally or inadvertently, identifies the persistent political rational for the introduction of instructional technologies. Callaghan (1962) referred to it simply as "the cult of efficiency".

Educational reformers in the 1980s who propose to "modernize" education by introducing the computer are merely recent expressions of a 70 year old theme. Pressey, in 1932, called for a revolution in education through the introduction of machines. Pressey felt the school needed the efficiency of the factory. Both he, and B.F. Skinner who amplified Pressey's original ideas, felt schools could benefit considerably from the application of scientific knowledge.

Robert Travers (1973), a respected educational psychologist, in examining the history of educational technology and its proponents, concluded that these technologies closely reflect the values of the sponsoring ruling class. Government-sponsored educational technologies were seen by Travers as "achieving the traditional goals of education more efficiently in educating more people at less cost" (House, 1974: 251). Ivor Davies (1981) pointed out one weakness of the efficiency concept. Efficiency needs to be coupled, Davies claimed, with the other side of the coin, effectiveness. Efficiency, explained Davies, is doing things right. Effectiveness is doing the right things. Educational technology, he concluded, too often ignores the far more significant question of effectiveness.

Both Ernest House and Travers identified four benefits which the ruling technocractic class would derive from the application of industrial technology to education:

(1) increased efficiency and productivity will reduce costs;
(2) the technology can convey a conservative message, implicitly or explicitly, supporting the status quo;
(3) schooling becomes a perpetual market for improvements to the technologies;
(4) a modernized school system would become dependent upon the providers of innovation and thus would be under control.

Travers' observation about the role of schooling in society is not unique to the study of the history of education. His extension of this analysis to identify the role which educational technology has played in recent years to reinforce the pacification role of schooling is an original adaptation.

The drive toward greater productivity in education - - the modernization of education - - requires the transformation from a labour-intensive to a capital-intensive operation. Teachers' unions have long suspected that labour reduction was the main objective behind the introduction of industrial strategies in the classroom. If the promise of greater efficiency and control have been the government's prime objectives to justify expenditures in new instructional technologies, are these the sole criteria for gauging educational improvement? Why have educational researchers studied the comparative effects of different instructional technologies on student learning? Is there any justification in supporting the "cult of efficiency"?

Instructional Technology Myths

> Film teaching will be done without any books whatsoever. The only textbook needed will be for the teacher's use. The films will serve as guide posts to those teacher's instructional books, not the books as guides to the films. The pupils will learn everything there is to learn ... By making every classroom and every assembly hall a movie show, one hundred percent attendance will be assured. Why you won't be able to keep boys and girls away from school. They'll get there ahead of time and will scramble for good seats, and they'll stay late, begging to see some of the films over again.
>
> - Thomas Edison,
> New York Times, 1919

This claim by Thomas Edison, made roughly sixty years ago, holds more than historical interest. It reflects the many beliefs and judgements generally held by educational media advocates today, and expressed in a great many publications extolling the virtues of CAI and other information media.

The dilemma facing both mediaphiles, like CAI supporters, and government planners, is that no instructional technology has ever delivered fully on its promises. Anthony Oettinger and Nikki Zapol (1972: 7) expressed the issue as follows:

> How can technology best help people learn as their own goals change along with social and economic conditions? The question is worth asking only if it is granted that technology can serve learning at all. ... Far from producing "visible results within a limited period of time," educational technology... has made no significant difference in learning achieved through formal schooling.

The notion that media do not affect learning seems unbelievable when one considers the impact that moveable type and the printed page have had on education. Applied effectively to groups of special needs learners some instructional technologies have produced demonstrable improvements. Generally, however, the "no significant difference" findings prevail (for example see MacLennan and Reid, 1964; Alderman, 1978.) Why then are we continually confronted with proposals for large scale implementations of instructional technologies?

In an intensive review of Scarborough College's experiment with televised lectures John Lee (1971: 1975) concluded that promised cost-effectiveness rather than a desire to improve instruction was the driving force. Is the push to "teach with computers" motivated by a similar cost-conscious concern on the part of government accountants? Whether or not the answer is affirmative, the movement to modernize instruction via CAI will find willing support from the educational technology sector.

Joel Rakow (1980) demonstrated that many leading US educational technologists have succumbed to a set of "audiovisual myths". The four he identified are: 1) that traditional methods of instruction are inherently bad; 2) that instructional media are the remedy; 3) that content conveyed by instructional media is of the greatest value to students; and 4) that traditional methods and instructional technology methods are mutually exclusive. While educators caught up in the excitement of implementing CAI will probably want to ignore Rakow, his empirical findings have direct implication on the manner in which the new information technologies are applied to education.

In the past forty years countless instructional technologies have come and gone, and they continue to be implemented, despite the apparent myths and the "no significant difference" findings. Most of the earlier instructional technologies are either now forgotten (e.g. teaching machines, EVR) or are greatly diminished (e.g. programmed instruction, 16mm film, instructional TV). We are left wondering whether the volumes of educational research on media effectiveness have been studying the wrong things for the wrong reasons. Their lack of impact would indeed seem to suggest that the crucial issues regarding the use of instructional technology are independent of learning methods and content. These studies may be more instrumental in distracting the attention of teachers and instructors to classroom issues and thus away from the underlying political efficiency rational motivating the automation of education.

A nagging question remains. If each new instructional technology has been supported by both an efficiency conscious government and by media proponents within the educational system, why have attempts to transform schooling failed so consistently?

Barriers to Change

The factors which have stymied past efforts to reform education are still operative in 1983. Hanna Mayer (1982) and Goodwin Watson (1972) have provided two comprehensive summaries of factors impeding the adoption of innovations.

Computer technology can be introduced into education in any or all of the following three ways: 1) teaching about computers; 2) teaching to use computers; and 3) teaching with computers. It is the latter application, which has a direct impact on the job description and performance of the teacher, which is primarily affected by tne following considerations:

Incentives for Change. Fernenc Janossy (1966) has drawn a conclusion from industrial innovation which has direct bearing on the rate and success of innovation in education. The transformation of concrete labour skills provides a resistance to innovation, Janossy observed. The time and energy required to implement this transformation is a measure of the resistence and affects the rate of diffusion of the innovation throughout the system.

Ernest House, after studying a project to introduce the PLATO CAI system into Chicago junior colleges, concluded that:

> The burden of innovation must inevitably fall on the teacher. The teacher must implement the innovation and learn the new skills that are required. Depending on how different the innovation is, the burden can be costly indeed, and benefits seldom approach costs. The teacher is expected to finance the innovation with personal effort, in effect depleting her professional skills without recompense, which represents a poor investment. In any case, innovation can be realized only through the changing work skills of the teaching work force, or it cannot be realized at all.
>
> (House, 1974: 171)

A study by the Lincoln County School Board of Ontario (1973) showed that trying to innovate in an economy of scarcity is next to impossible. Adequate incentives for teachers which must be available include opportunities for advancement, for increased authority, special assignments, release time, and study leaves, as well as more conventional remunerative considerations. Even

if aware of these necessities administrators are often unwilling to provide additional resources and incentives since the original rational for introducing an instructional technology usually is to save money.

Educational administrators have been extremely negligent in attending to the wide range of human factors issues associated with the implementation of innovation.

Attitudes about Learning. Utopian predictions regarding the likely impact of computers and telecommunications on the teaching-learning process tend to discuss the tool as independent of the user. This is a fallacy. The effective, appropriate and imaginative application of any tool depends upon the values, goals, objectives, skills and creativity of the user. Without a sufficiently enlightened and progressive philosophy of education any instructional technology can be neatly fitted into the existing order.

House argued, as have other authors such as Russell Ackoff (1974), that most CAI maintains the autocratic, teacher-centered, tedious, rote memory approach to education. Granted, CAI can be much more but so too can other educational innovations. Lee's case study of educational television at Scarborough College showed that most professors failed to alter their "live" lecture style when being taped by the television camera. One watches with amazement as elementary teachers subvert LOGO's intended purpose and integrate it into curriculum-based education. Many instructors when introduced to the open-concept classroom design in the early seventies immediately reverted to their learned habits and set up conventional classroom situations. Professors usually insist on lecturing as part of a teleconferencing course despite the unequivocal evidence against this approach. The litany of misused innovations goes on and on.

The contributing factor in each of the above situations was the failure of those initiating the educational innovation to support adequately the need of the user to acquire the necessary skills, attitudes and behaviors to apply the new instructional technology or method effectively.

Several experiences at Scarborough College which are reported by Lee would also present dilemmas if encountered during the current mission to implement CAI in schools. For example, university professors balked at the suggestions of the TV directors that showmanship be incorporated in their telelectures. Many professors held the view that lecturing and learning are serious business. It was the student's responsibility to grapple with the material, they argued, and not the lecturer's task to provide extrinsic motivation. Applied to CAI this philosophy would result in sterile programs devoid of directions, animation, graphics, humour and textual encouragements

Lee also noted that had the Scarborough telelecture experiment been a success in its pure lecagogical questions. At what point, Lee pondered, must learners disengage from an instructional technology in order to reconcile the dialectic conflict between their perspective and the mediated information? Media like TV or CAI which totally capture learners in a pseudo-interative information flow do not force learners to reformulate their concepts and paradigms, or to apply knowledge and analytical skills to resolve unique problems.

Pressures of Economization. Invariably the all-out drive to achieve economization by implementing an instructional technology presents unrealistic limitations which undermine the innovation process (Moore and Hunt, 1980). Lee reported that the Scarborough College administrators worked out a formula for telelecture production based on triple the amount of time required to prepare a regular live lecture. In practice, however, good professors found they required ten times the amount of time. Without adequate compensation or recognition, or a re-assessment of the original resource formula, the innovative few gradually stopped infusing the amount of time and energy required to produce a good TV lecture.

Similar problems are occuring with CAI. Almost everyone involved in computer literacy and courseware development has been content to allow teachers to believe that high quality courseware can be produced by individual teachers. Industry experience that multi-specialist teams must invest 300 person-hours per one hour of actual instruction has not sufficiently informed school board decision-makers prior to their making commitments to purchase hardware.

Economies of Scale. Large expensive media like television or computers require uniformity and stability of curriculum in order to be economical. Rapid changes in knowledge or curriculum reform threaten stability. This scares away producers of quality courseware who fear they will fail to acheive a reasonable return on their investment. The best market, as far as edubusiness is concerned, is one in which the producer, not the consumer, determines the nature and rate of change in the courseware product.

Another factor is the "scale of aggregation" (Oettinger and Zapol, 1972). Unit costs of a product generally decrease as the quantity of the product produced increases. Policy makers and commercial interests obviously prefer the lower costs made possible by mass production. The result is what House termed a form of "cultural imperialism". Pressure is placed upon minority groups and communities by educational administrators to integrate into the efficient mass produced educational system. The morality of modern instructional technologies, House concluded, is suspect. The pressure toward integration has been resisted by the decentralized educational jurisdictions and the educator's fundamental preference for meeting the needs and demands of groups of individuals.

vations affecting the performance of labour must inevitably confront the existing structure and relationships within an organization. Schools have built-in barriers at many levels which have often thwarted the implementation of instructional technologies.

Lee noted that efforts to implement televised lectures in both universities and secondary schools often failed to deal with the difference between the standard timetable class length and the optimal length for an effective, enriched telelecture.

By contrast industrial managers long ago learned that the characteristics of individual jobs have to determine the job routine. This is currently illustrated by the emerging work pattern for word processing operators -- 50 minutes of key entry, 10 minutes change of duty -- which differs significantly from the conventional typing pool work schedule.

Efforts to modernize education have also been frustrated, House stated, by the "traditional" structure of the institution. Despite the large educational bureaucracy the teacher is relatively autonomous, there is little true quality control, and skills are learned largely through imitation. This is particularly the case in higher education. Without adequate role models to emulate, often with a peer group unsupportive of innovation and jealous of individual excellence, coupled with the individual burden to implement innovation, there is little support for the individual instructor to innovate.

House described the model of innovation adoption in schools as a top-down process. He termed this "structural imperialism". His observation was confirmed by an extensive study conducted in Wisconsin (Barrows, etal, 1979), although the Wisconsin results also demonstrated the power of the teacher. Principals generally make the decision regarding innovation in the school, after such decisions regarding innovation in the school, after such decisions are passed down to them. The Wisconsin study, among others, concluded that teachers ultimately hold the final say over implementation of an innovation because of their ability to subvert it in the classroom. Thus while teachers may appear to aquiese to the principal, when decisions are made they possess the real power.

Producers and advocates of innovative instructional technologies invariably select inappropriate "change agents" within the school organization. For instance, teachers first attracted to microcomputers may be totally unrepresentative of the rank and file. Moreover, they may lack credibility amount their peers. Since, as countless studies have confirmed, personal contact is the most important means of diffusing innovation, early adopters of microcomputers may be unable to influence many of their colleagues.

Courseware Quality. The reliability of microcomputer hardware has increase significantly. However, courseware quality has been sadly lacking. This has been caused in part by the general preoccupation with media hardware and with the technology itself. The tendency of administrators to cut media before labour during austerity periods (the University of Toronto eliminated is TV production unit in May 1983), and to allocate insufficient funds for software/courseware procurement, has made education an unreliable market. Without a firm market commitment from education good producers and talented personnel thus tend to concentrate on other more lucrative and promising markets (Hooper, 1969).

CAI courseware quality also suffers due to the poor qualifications of most developers. Few courseware developers can match their interest in computers and programming with an equal amount of knowledge of learning theory and experience in instructional design. The results for CAI to date closely parallel the experience with programmed instruction (PI) in the Fifties. As the quantity of PI packages increased, the quality rapidly decreased. Faced with unreliable products educators ceased to use the PI materials, and signaled their administrators to stop making further purchases. There is little indication to date that CAI has overcome this limitation.

Consolidating Innovation

The process of change can be visualized as a movement from one level or state to another. Various researchers have agreed that it is a multi-stage process which culminates generally in a decision. There are three basic options: 1) adopt the innovation; 2) adopt with modification: or 3) reject the innovation. The decision stage can be affected by countless variables. We have summarized some of these in the preceding section. The requirements to ensure the adoption or consolidation of an innovation are as complex as they are elusive. The following are some lessons gained from attempts to implement instructional technology innovations during the past two decades which have relevance for the educational computing field:

1) The introduction of "big media" requires strong political support.
2) Decision- makers must be prepared to amortize the high capital start-up costs over a long period of time.
3) The use of sophisticated media for instruction requires well-trained, skilled staff, and an extensive infrastructure and educational support system.
4) The cost of accessing the media must be reasonably estimated based on adequate production guidelines and cost-effective means of distribution or communication in order to reach the largest possible audience (Cory, 1980; Purdy, 1980)
5) Close attention must be paid to the psychological and affective factors which undergird communication (Mooney and Carpenter, 1979; Short, etal, 1976; Lee 1975).
6) Teachers must receive adequate information about an innovation, training in its use, curriculum materials to assist in

integrating the application, and long-term support services to bridge the transition period. Provision of various forms of incentives must also be determined.

7) Pure efficiency justifications can be overcome by ensuring that long-term course-ware production is well designed and compatible with a well-conceived philosophy of application. An emerging consensus for computer applications in education in France, England and Ontario stresses creative and productive applications, word processing, information access and processing, simulations, and problem generation and solving. The tutorial replication of programmed instruction designs is being limited to selected applications.

Conclusion

The history of educational technology is littered with the failure to integrate educational media into the traditional teaching environment of the classroom. Hundreds of research studies concerning the impact of instructional technology on the learning process have, at best, produced "no significant differences". The educational institution is depicted as a "traditional" organization which is extremely conservative and which divests large amounts of autonomy in the individual. In universities this status quo is maintained by the oldest guild system still in existence. These organizational characteristics, coupled with numerous other factors, have acted as a resilient barrier to educational reform, despite the attempts of innovators and government bureaucrats to increase the efficiency and the productivity of education.

The implementation of computer-based instruction will require considerable care, imagination, expertise and perseverence if the outcome is to differ from the pessimistic view Richard Hooper expressed following a lengthy study tour of the United States:

> The newer technologies are failing to penetrate the American educational system. But the cries of frustration which echo with monotonous regularity around media convention halls seldom lead to any real diagnosis of failure.
>
> (Hooper, 1969: 245)

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